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WINDING CORE FOR LINEAR MOTORS

INS A1

[0001] The invention relates to a winding core for linear motors, having a yoke and protruding teeth for formation of slots for receiving a winding. Such winding cores are used for the active and/or reactive parts of linear motors (also designated as primary parts and secondary parts).

[0002] The flux density of the magnetic field induced by the winding can become very great in the teeth of such winding cores. The magnetic flux density may hereby increase to such an extent that the saturation magnetization for the material of the winding core is reached, thereby decreasing the efficiency of the linear motor.

[0003] In order to reduce the magnetic flux density in the tooth, the tooth cross section can be enlarged. When the tooth cross section is enlarged in movement direction of the linear motor, the slot widths are hereby decreased, resulting, on the one hand, in an increase of the flux leakage across the slot in view of the smaller distance between the teeth. Moreover, there is less space in the slots for the winding. Further, the hysteresis loss increases in the tooth as a consequence of the greater tooth mass.

[0004] A further possibility to reduce the magnetic flux density in the tooth is an enlargement of its lateral cross section perpendicular to the movement

direction of the motor. This, too, results, however, in an increased flux leakage across the slot. Moreover, this measure also leads to an increase in tooth mass, resulting in a higher dissipation.

INS A2

[0005] It is an object of the present invention to effectively eliminate the afore-stated drawbacks and to reduce the magnetic flux density in the tooth.

[0006] This object is attained ~~by a winding core according to claim 1.~~

[0007] The solution is based on the recognition that the flux density in the tooth is the greatest in the portion adjacent to the yoke and decreases with increasing distance from the yoke as a consequence of the increasing flux leakage across the slot.

[0008] The teeth have thus a yoke-proximal portion and a yoke-distal portion. The yoke-proximal portion is widened with respect to the yoke-distal portion laterally in the direction perpendicular to the movement direction of the linear motor. In this way, the cross sectional area of the teeth is enlarged in a zone where the magnetic flux density is the highest. On the other hand, the tooth cross section is not enlarged in a zone where the flux leakage across the slot is the highest, namely in the yoke-distal portion of the teeth.

[0009] The widening of the yoke-proximal ends of the teeth amounts, preferably, to about 10%.

[0010] In particular, the widening may be implemented symmetrically on both sides of the teeth.

[0011] The widening of the teeth may be realized in the form of at least one shoulder. In particular, the at least one shoulder is not distanced from the yoke any farther than half the tooth length.

[0012] As an alternative, the widening of the teeth may also be realized via a slanted shoulder.

INS A3

[0013] Embodiments will now be described in more detail with reference to the figures.

[0014] FIG. 1 shows the distribution of the flux density in a winding core according to the prior art;

[0015] FIG. 2 shows a side view of a first exemplified embodiment of the winding core according to the invention perpendicular to the movement direction of the motor;

[0016] FIG. 3 shows a vertical section of the first exemplified embodiment transversely to the movement direction of the motor through the yoke and a tooth of the winding core;

[0017] FIG. 4 shows a vertical section of a second exemplified embodiment of the winding core according to the invention transversely to the movement direction of the motor through the yoke and a tooth of the winding core.

INS A4

[0018] FIG. 1 illustrates the distribution of the flux density in a conventional winding core 1 (here the primary or active part), with the windings (not shown) receiving electric current. Reference numeral 2 denotes the reactive part (or secondary part) of the linear motor. The reactive part and the active part interact in a known manner.

[0019] The winding core includes a yoke 3 and teeth 4, with slots 5 being formed therebetween. It can be seen from the figure with respect to the center tooth that the magnetic flux density is the greatest in the region of the tooth 4, which adjoins the yoke 3. The flux density decreases with increasing distance from the yoke as a consequence of the flux leakage across the slot, which flux leakage increases between the teeth 4 as the distance from the yoke 3 increases.

[0020] FIG. 2 shows a side view, perpendicular to the movement direction according to the first exemplified embodiment of the winding core 1 according to the invention. The illustrated winding core 1 includes a return yoke 3 with protruding teeth 4. The teeth 4 define the boundaries for the slots 5 which receive the winding (not shown), i.e. the winding (or windings), are thus guided around the teeth.

[0021] The teeth 4 are wider on their yoke-proximal portion 7 than on their yoke-distal portion 6 (FIG. 3). The transition between both these portions 6 and 7 is configured as shoulder 8 having a smaller distance from the yoke 3 than its distance from the yoke-distal end surface 9 of the tooth 4. The windings (not shown) are so configured as to be wound around the widened portion 7 as well as around the non-widened portion 6.

[0022] The above-described configuration of the tooth results in a decrease of the magnetic flux density in the portion 7, without increasing the flux leakage across the slot in the area of the portion 6. The increase in tooth mass as a consequence of the enlargement of the portion 7 with respect to the portion 6 is fairly small compared to the overall mass of the tooth 4 so that dissipation as a consequence of hysteresis losses is only slightly increased.

[0023] The second exemplified embodiment (FIG. 4) differs from the first one only in that the transition between the yoke-distal portion 6' to the yoke-proximal portion 7' is realized via a slanted shoulder 10.

[0024] The configurations of the transition from the yoke-distal portion to the wider yoke-proximal portion of the tooth, as shown in both exemplified embodiments, are not the only options. For example, multiple shoulders or transitions with continuous or curved configurations are possible. The continuous widening may already commence on the yoke-distal end surface of the tooth, when the transitions are continuous from the yoke-distal portion to the yoke-proximal, wider portion. Also, there is no need for the tooth configuration to be symmetrical. It is, for example, possible that the transition to the wide portion of the tooth is different on both tooth sides, or only provided on one side of the tooth.

[0025] As shown in the sections according to FIGS. 3 and 4, the winding cores are each made of individual, stacked metal sheets. The tooth enlargements are hereby so realized that the respectively last lateral metal sheets (in the illustration 4 on each side) have different tooth lengths compared to all the remaining ones; multiple shoulders can hereby be realized by providing these metal sheets with different (outwardly decreasing) tooth lengths.

[0026] To clearly show the tooth lengths, the slot base is shown as continuous line in each of FIGS. 3 and 4.

[0027] FIG. 1 depicts that the flux density in the yoke-proximal portion of the tooth, directly adjacent the slot 5 and the yoke 3, is the greatest; this has been confirmed through calculation by using the finite element method, and FIG. 1 is based on such a calculation. It would thus basically be sufficient to widen only the respective portion of the teeth to reduce the flux density below the saturation magnetization.

[0028] In the illustrated exemplified embodiments, the yoke is, however, widened in addition over the entire length of the winding core so that also in this case the flux density is reduced. This can also be exploited on the other hand to reduce the height or thickness of the yoke 3 (perpendicular in the figures) because the hereby accompanying increase in flux density can be compensated by yoke enlargement. In this manner, linear motors of flatter configuration can be realized.

[0029] Furthermore, the widening of the yoke 3 between the teeth 4 may, for example, also be omitted so that the yoke does not exhibit a uniform width over the length of the linear motor, and material (and thus mass) can be saved.